WEST AFRICAN COCOA RESEARCH INSTITUTE

QUARTERLY PROGRESS REPORT

No. 43

TAFO, GOLD COAST.

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WEST AFRICAN COCOA RESEARCH INSTITUTE

TAFO

FORTY-THIRD QUARTERLY REPORT : JULY-SEPTEMBER, 1956

SENIOR STAFF

Director	:	J. Lamb
Secretary	:	H. L. Pugh (arrived 24th July)
Acting Secretary	:	R. J. Webb (returned to the U.K. on 20th August)
Director's Secretary/Librarian		Audrey Bryan (arrived 9th August)

TAFO STATION

Division of Entomology	:	D. J. Taylor P. F. Entwistle Helen M. Entwistle
Division of Pathology	:	W. T. Dale A. L. Wharton G. Usher A. Attafuah (returned from leave 20th September)
Division of Botany	:	A. D. McKelvie D. R. Glendinning (arrived 24th July)
Division of Soil Science and Chemistry	:	T. A. Rohan (returned from leave 16th August) E. Margaret Holden (returned from leave 28th July) P. W. Arnold
Division of Agronomy	:	R. J. Benstead (on leave)
Plantations Manager	:	H.W.S. Allison (arrived 25th August)
Guide-Demonstrator	:	F. E. Decker
Station Manager	:	S. E. Ntim-Kwafo

IBADAN SUB-STATION

Entomologist (Acting Officer-in-Charge)	:	R. G. Donald
Pathologist	:	J. M. Thresh

MANAGING COMMITTEE

The twentieth meeting of the Managing Committee was held at Ibadan on 16th August and was attended by the Director, Mr. Webb and Mr. Pugh. The Technical Sub-committee met on 14th August.

STAFF MATTERS

Four new members of senior staff arrived during the quarter. Mr. H.L. Pugh assumed duty as Secretary of the Institute and Mr. R.J. Webb, who had been seconded by the Crown Agents until a permanent appointment was made, returned to the United Kingdom on leave. Mr. D.R. Glendinning, the new Plant Breeder, took up his duties at Tafo in July, after having spent several months at the Plant Breeding Institute at Cambridge. Mr. H.W.S. Allison and Miss A. Bryan arrived in August to take up their appointments as Plantations Manager and Director's Secretary/Librarian, respectively.

VISITORS

Dr. W. Carter of the Pineapple Research Institute, Honolulu, who was a member of the 1948 Commission of Enquiry into the Swollen Shoot Disease of Cacao in the Gold Coast, spent the whole of the quarter at the Institute. He came to evaluate and assist the research programme of the Entomology Division and to serve as adviser to the Director.

Dr. G.D.H. Bell, Director of the Plant Breeding Institute at Cambridge and Mr. H.H. Rogers, who was formerly a plant breeder at W.A.C.R.I., spent three weeks at Tafo to advise on the breeding programme. Mr. F.W. Cope, Senior Plant Breeder (Cocoa) of the West Indian Regional Research Centre, I.C.T.A., Trinidad, arrived at the end of September for a stay of several weeks in order to carry out investigations into the incompatibility mechanism in Upper Amazon cacao.

The Minister of Agriculture accompanied by Mr. E.S. Packham visited the Tafo Station on 21st September. Commander Sir Robert Jackson, of the Volta River Project Preparatory Commission with Mr. R.E. Walker, Regional Officer, Eastern Region, visited the Institute in August.

Dr. B.O.L. Duke from the Helminthiasis Research Unit, British Cameroons, spent several days during August investigating the incidence of filarial infections in the Tafo neighbourhood. Other visitors to Tafo have included two British M.Ps. Mr. C. Pannell and Mr. N. Pannell.

On September 6th and 7th a meeting of the Fertilizer Sub-committee of the Technical Advisory Committee for the Development of Agriculture and Natural Resources (Gold Coast) was organised at W.A.C.R.I. The programme included visits to the Agricultural Development Corporation's 1,000-acre Cocoa Plantation Area at Kukurantumi and to the Pineapple Area near Nsawam.

MANAGEMENT AND MAINTENANCE

There was a small reduction of the labour force following the handing over of the Out-stations to the Department of Agriculture.

Bungalows .../

Bungalows 3 and 17 were re-decorated and minor repairs were carried out on a number of houses in the Residential Area and WACRI Village at Tafo. A new garage block has been built for the fire extinguisher and one truck.

The average daily production and consumption of water at the Tafo Station were as follows :-

	Production	Consumption
July ...	23,592 gallons	19,703 gallons
August ...	24,836 "	21,955 "
September ...	25,310 "	21,297 "

CROP DELIVERY

Harvesting of the Minor Crop on the Uniformity Trial areas ceased at the beginning of August, after completing nine pickings. The Main Crop harvests began on 20th August and four pickings have so far been completed. The following table gives figures for the total Minor Crop and the four Main Crop pickings :-

MINOR CROP

Total Pods		Pods discarded %	Pods fermented	Wet wt. of beans lb.	Dry wt. of beans lb.	Pods issued for experiments
Harvested	Discarded					
18,812	712	3.8	18,100	4188.6	1686.4	-

MAIN CROP

Date of Picking	Total Pods		Pods discarded %	Pods fermented	Wet wt. of beans lb.	Dry wt. of beans lb.	Pods issued for experiments
	Harvested	Discarded					
Aug. 20-22	8,834	314	3.6	8,520	2025.0	-	-
Sept. 3- 7	16,584	754	4.5	15,580	3608.4	-	250
" 10-14	16,476	754	4.6	15,472	3549.8	-	250
" 17-21	21,421	844	3.9	20,327	4593.9	-	250
Total	63,315	2,666	4.2	59,899	13777.1	Not ready	750

SWOLLEN .../

SWOLLEN SHOOT DISEASE

The numbers of trees removed during the quarter, due to virus infection and other causes, are shown in the following table :

Old Station				Square Mile			
Month	Diseased	Other Causes	Total	Diseased	Contacts	Suspects	Total
July	26	21	47	147	52	14	213
August	36	11	47	220	61	28	309
September	23	14	37	112	41	14	167
Total	85	46	131	479	154	56	689

A further 54 infected seedlings were rogued from the Old Station.

OUT-STATIONS

After discussions with the Department of Agriculture the four W.A.C.R.I. out-stations at Koransang, Adonkwanta, Akwadum and Nankese were, on the 1st August, 1956, handed over to the Department for upkeep and maintenance.

The out-station farm at Kukua was returned to the owner at his request.

METEOROLOGY

The rainfall records for the quarter at Tafo are compared with the eighteen-year means.

Month	1956		18-year mean	
	Rainfall (in.)	Wet days	Rainfall (in.)	Wet days
July	1.01	9	5.47	13.8
August	0.69	10	2.62	13.0
September	4.68	14	6.25	14.7
Total	6.38	33	14.34	41.5

UPPER AMAZON SEED

A total of 3,590 F3 pods was despatched to the Regional Departments of Agriculture, Nigeria.

VIRUS .../

TAFO STATION

1. VIRUS RESEARCH

Host Range of Cacao Viruses

Seedlings derived from three more spineless Ceiba trees (see Quarterly Report No.41) have been experimentally infected with the New Juaben and Kpeve viruses. Two of the trees were at Sambu (N. Togoland) and the other was at Ilorin (Nigeria). Pods collected from one of the Sambu trees were of the elongated type thought to be associated with C. guineensis A. Chev. Bombax costatum Pellegr. & Vuillet (Bombacaceae), a fairly common tree in the Northern Territories of the Gold Coast, has proved susceptible to New Juaben in laboratory tests on young seedlings. These developed leaf mosaic and soon died, probably due to the infection. A second malvaceous plant, Hibiscus abelmoschus L., has shown susceptibility; though no symptoms appeared, and virus was only detected by 'back-tests' at two and three months after 'bombardment'. The susceptibility of herbaceous or semi-herbaceous hosts in the Malvaceae and Tiliaceae, though interesting, is probably of no practical significance.

Insect Transmission Studies

Planococcus citri Risso can transmit the Adansonia virus isolates AD7, 14, and 191 (Wusuta), but Ferrisiana virgata (Ckll.) has not so far proved capable of transmitting either these three or AD36. This is interesting in view of the insect's inability to transmit the Kpeve and Alaparun cacao viruses, symptoms of which closely resemble those produced in cacao by the Adansonia isolates. The Aiyiboso (Gold Coast Western Province) cacao virus has been transmitted by F. virgata, and a mild isolate from Osino (Eastern Province) by Pseudococcus njalensis Laing.

When first-instar nymphs of P. njalensis were removed, on hatching, from adults colonizing plants infected with the New Juaben virus, they produced no infections when transferred to 66 dissected cocoa beans at the rate of ten per bean. There was thus no evidence of transmission from infective vectors to their progenies, which is not surprising in view of the short period the virus is known to persist in the feeding mealybug (Posnette & Robertson, Ann. appl. Biol., 37, p.363, 1950).

Classification of Viruses and Virus Strains

It has been suggested that establishment of a virulent strain of the New Juaben virus in young seedlings already infected with a mild one (see Quarterly Reports Nos. 38-40) resulted from giving the latter insufficient time to become fully systemic before challenging with the former. This seems unlikely; but an attempt has been made, using 50 nymphs of P. njalensis per plant, to establish the virulent strain in five basket-seedlings infected with the mild one more than 14 months previously.

In August 1953, test saplings were patch-grafted with material from a suspected virus outbreak at Worawora in British Mandated Togoland; three years later, one has

two .../

two small swellings. The plant was under frequent observation for the first nine months after grafting but has been examined only occasionally since; so it is possible, though unlikely, that earlier symptoms have been overlooked.

Four outbreaks in the Akwapim area of the Gold Coast have been examined. Leaf symptoms in three of these, one at Mamfe and two at Mampong, were characteristic of the virus collected from the area by Mr. J. Paine in 1945 and named after the latter place. The incidence of swellings varied. Little is known of the effects of this virus in the field. Defoliation of the trees was evident, though some were bearing a fair crop. It is likely that these outbreaks are some of the ones surveyed by Paine; if so, the virus does not cause the early death of cacao. In another outbreak near Mamfe, a short distance north of the first, there were dead and dying trees, many of which were evidently infected with both the Mampong and virulent New Juaben viruses. It would seem that the latter has recently spread southwards into the area.

Resistance and Tolerance

Only one out of 26 rooted cuttings derived from Iquitos-type plants infected with the New Juaben virus, but exhibiting mild symptoms, has given visible evidence of infection in the first flush. The symptomless plants are being tested for the presence of virus.

In Quarterly Report No.41, the number of uninfected cuttings in the first replicate of the experiment to compare resistance and tolerance in 50 F1 Iquitos-type (T17) seedling trees was given as 30; but 13 of these cuttings have since produced symptoms, in spite of having given negative 'back-test' results. Another died too soon for a reliable diagnosis to be made, leaving 16 apparently virus-free plants. It is disappointing to find that the 'back-testing' technique (Ann. Rep. WACRI, 1954-55, p.44) is fallible. Failure seems to occur with two kinds of plants: firstly, those making poor growth and therefore devoid of succulent tissues rich in available virus; secondly, those producing only slight symptoms after a long delay, in which the concentration of virus available to vectors may be low or unevenly distributed.

Cuttings in the second replicate have now been scored for resistance. Judging from symptoms and 'back-test' results, only 12 of the 250 plants seem to have escaped infection. Considering both replicates together, the 29 cuttings remaining apparently virus-free are derived from the following F1 trees (the bracketed figures denoting the numbers concerned for each replicate): T17/448 (2, 1); 359 (1, 2); 1219, 2626 (3, 0); 1159 (1, 1); 1071 (0, 2); 434, 1130, 1132, 2628, 2651, 2655 (1, 0); 358, 1131, 1157, 2627, 2630, 2652 (0, 1).

The infected plants in both replicates have also been scored for tolerance. Some (rated 0) were severely stunted and showed pronounced symptoms, comparable with those of Amelonado. Many (1) had symptoms of intermediate severity (slight stunting, usually associated with large swellings and mild leaf symptoms or marked leaf symptoms

with .../

with or without small swellings). Others (2) had mild though quite obvious and regularly appearing leaf symptoms and/or small swellings. The remainder had only evanescent or hardly detectable leaf symptoms (3), or (up to the time of scoring) none at all (4), infection in the latter being diagnosed by 'back-tests'. The mean score for the 50 F1 parents in the two replicates varied from 0.40 to 2.80 out of four. Amongst the more tolerant were T17/532, 1888, 524, 2630, 523, 1220 and 2628; those least so included T17/1219, 522, 357, 1855, 1218, 521 and 1132. Intensity of leaf symptoms and development of stem swellings did not seem to be closely associated, and though plants with the latter usually had large root swellings this was not always so. Thus far, there is no evidence that tolerance and resistance are correlated.

Chemical Detection of Cacao Virus Infection

No further work on this line of investigation is being undertaken at present.

A study of flavonoid compounds of the cacao leaf which arose out of the investigation of the Tinsley-Usher 'colour-test' for detecting swollen shoot infection is being concluded. The four anthoxanthin pigments of Amelonado cacao leaves have now been separated, by a combination of column - and paper chromatography, in amounts which should be sufficient for them to be identified.

Chemotherapy

Thiouracil is being tested for its effect on infection with swollen shoot virus, since it has been shown that in other species it has a marked effect in reducing virus concentration and symptoms.

To investigate possible phytotoxic effects batches of healthy beans were soaked for 15 min. in solutions of 20, 100, 500 mg./l. and then planted. The highest concentration retarded germination compared with the untreated controls (C). Another batch of beans (T) was germinated for 1 week and then watered daily for a fortnight with a 100 mg./l. solution of thiouracil. This concentration had a marked phytotoxic effect. Seedlings C and T were then bombarded with mealybugs from a virus source. Half the batch C seedlings and all batch T were watered daily with a 50 mg./l. solution of thiouracil. It is too early yet for symptoms of infection to have appeared.

'Thimet' [O, O, diethyl S- (ethyl thiomethyl) phosphorodithioate], a systemic insecticide, which has been found to affect the growth of several plant species has been tested on cacao. Beans which were soaked for 10 min. in a solution (1 in 10 dilution of 47.5% emulsifiable concentrate) of 'Thimet' germinated more rapidly than untreated beans but when the seedlings were five weeks old there was no difference in size between the two groups.

Seedlings infected with the New Juaben virus which were watered with a solution of 'Thimet' showed severer symptoms than the untreated controls.

3. .../

3. STUDIES ON BLACK-POD DISEASE

(a) Fungicidal Control Trials

A large proportion of the year's crop has been harvested during the quarter on the cacao areas included in Trial I. The records are sufficiently interesting to warrant tabulation in detail. The following table gives the mean yield in pods per tree for each treatment, and the various categories of pods harvested are expressed as percentages of these mean yields.

Pod Yields - Trial I

Fungicide	Frequency of application	Frequency of harvesting	Mean yield	Damaged % *	'Black-pods' % *	Rodent-damaged % *	Otherwise damaged % *
Unsprayed (control)	-	Weekly	40.2	24.4	13.4	6.0	5.0
		Monthly	33.1	39.9	23.3	12.4	4.2
Carbide-Bordeaux mixture	F1	Weekly	33.6	16.4	1.8	9.2	5.4
		Monthly	31.1	13.5	4.8	6.4	2.3
	F2	Weekly	37.5	12.0	2.7	5.9	3.4
		Monthly	35.8	24.3	4.7	16.8	2.8
	F3	Weekly	46.1	16.9	4.1	8.7	4.1
		Monthly	36.6	25.1	7.1	14.2	3.8
Ordinary Bordeaux mixture	F1	Weekly	46.9	11.7	4.5	3.8	3.4
		Monthly	42.0	30.0	7.4	18.6	4.0
	F2	Weekly	22.3	22.0	6.7	8.5	6.8
		Monthly	44.0	23.4	8.6	11.1	3.7
	F3	Weekly	41.9	14.8	6.7	4.5	3.6
		Monthly	30.6	33.7	8.8	14.1	10.8
Perenox	F1	Weekly	50.0	14.8	3.0	7.4	4.4
		Monthly	36.0	25.6	5.8	15.6	4.2
	F2	Weekly	33.0	19.1	6.4	8.5	4.2
		Monthly	27.1	21.8	8.9	9.6	3.3
	F3	Weekly	34.9	16.3	6.6	6.0	3.7
		Monthly	29.8	18.1	9.4	6.4	2.3

* Classified pods as a percentage of mean yield.
F1 24 applications per annum - weekly, fortnightly or monthly depending on the seasonal incidence of black-pod disease.
F2 8 fortnightly applications from May to August.
F3 12 monthly applications.

Compared.../

Compared with the corresponding quarter in 1955, at least twice as many pods have been harvested for all the treatments; but the incidence of black-pod disease on the unsprayed plots has been low compared with previous years. All the fungicidal treatments are confirming the results achieved last year. Carbide-Bordeaux mixture has again been the most effective; but the control achieved by ordinary Bordeaux mixture and Perenox has much improved. Despite the small numbers of diseased pods on the sprayed plots there are differences between the three frequencies of application, in the expected direction, for each fungicide. Reduced incidence of black-pod disease as a result of weekly harvesting is again pronounced on the unsprayed plots and is apparent for each spraying treatment. Weekly harvesting has also tended to lower pod losses due to rodent attack (cf. Ann. Rep. WACRI, 1954-55).

Results from the small-scale fungicidal control experiment, Trial III, are proving anomalous and inconclusive, due to the low incidence of disease recorded for the unsprayed control plots. For the same reason, no results are forthcoming from Trial IV, which involved spraying pods with a 20% aqueous solution of a vinyl latex resin.

Cushion Infection

So far this year, the records from the second 'pod-painting' experiment, to investigate what proportion of proximal pod infections can be attributed to Phytophthora palmivora Butl. spreading from diseased cushions, closely agree with those from the first experiment (cf. Quarterly Report No.40), although the general level of the disease on the plots used has been much lower.

Effect of Age and Size of Pod on Susceptibility

Setting of the 1956/57 crop on the 200 trees included in this experiment has finished, and altogether over 4,500 fruits have been labelled for recording. Results can only be assessed at the end of the year. Records of fruits on trees subsequently lost due to swollen-shoot disease (seven during the quarter) must be discarded for the whole year, making progressive summaries of the figures impossible. During the quarter many fruits ripened and were left on the trees for a further six weeks before harvesting. Numerous infections amongst such ripe pods have confirmed that fruits at all stages of growth are susceptible to natural infection by P. palmivora.

4. CAPSID STUDIES

Population Studies

The experiments, first set up in January 1956, to investigate the possibilities of capsid population estimation by egg counts are continuing.

Egg .../

Egg Studies

Vertical Distribution of Eggs

A plot of mature cacao trees has been thinned from its original 4' by 4' spacing so that the effect of increased light intensity in the lower canopy on the vertical distribution of capsid eggs can be studied. Work will start as soon as populations reach a suitably high level.

Feeding and Oviposition

The relationship between feeding and oviposition on fan and on chupon tissue is being investigated. Figures obtained so far show a strong correlation (P=.001) between lesions per foot, and eggs per foot, of fan tissue. Correlation between these two factors in chupon tissue is not so good and final interpretation will be left until more data are available.

Oviposition Preferences

(a) A basic relationship is apparent between the percentage of all eggs in a plot of cacao that are laid in chupons and the proportion of chupon to fan tissue in that plot. A graphical representation of the data, where the proportion of chupon/fan tissue is plotted as the independent variable and percentage eggs in chupons as the ordinate, shows a curve that is asymptotic to the former factor. Two points on the graph can be determined theoretically: obviously in unjorqueted cacao seedlings all eggs present must be in chupon tissue, whilst in a plot of hypothetical mature cacao, in which all the chupons have jorqueted and fan tissue alone remains suitable for oviposition, all the eggs will be in fans. These two theoretical points are the first and last, respectively, in the following table :-

Chupons/Fans	1:0.00	1:1.45	1:4.62	1:5.00	1:38.52	1:∞
% Eggs in chupons	100.00	66.70	50.09	40.13	19.62	0.00

(b) Even in areas of cacao where capsid populations are high, competition for breeding sites seems to be negligible. If such competition does exist it should be identifiable as a correlation between the length, for example, of a chupon and the number of eggs laid in it. However, if calculations are made for the correlation coefficient between chupons, divided into groups of increasing length, and the mean number of eggs laid in each length group, the value obtained for 'p' is not significant. Similar calculations for fan tissue yield results that are even less statistically probable. This is not surprising when it is recalled that an average of two bugs to a tree indicates a large population.

Periodicity of Oviposition

The possibility that oviposition in the Bryocorine Capsidae associated with cacao follows a fixed pattern or periodicity is being investigated in the laboratory. Mature mated females are provided with cherelles, upon which they will feed and lay eggs, and these are changed four times

during .../

during each twenty-four hour period. Egg and lesion counts are made when each old cherelle is removed.

Capsid Rearing

Due to the high mortality of capsids during the pre-maturity period of adult life spent under laboratory conditions, and the large number of seedlings expended in obtaining eggs (Quarterly Report No.40), a more efficient culture method is being sought.

Rearing newly moulted adults on cherelles with controlled conditions of high humidity, and also using cherelles as a substrate for oviposition, seems to promise a feasible and compact method. The greatest problem encountered has been that of maintaining surface-sterile conditions on the cherelles without demaging the eggs during their incubation period. Various standard fungicides are being tried.

Joint W.A.C.R.I. - Department of Agriculture Insecticides Trial

A comparative trial was commenced during the quarter in co-operation with the Department of Agriculture. The trial has been designed to investigate the relative values of five related insecticides in the control of capsids in mature cacao. In assessing the value of each insecticide its efficiency will be considered in relation to its cost.

The insecticides under test are Aldrin, Dieldrin, Endrin, Heptachlor and gamma-BHC. The first four are being compared with the gamma-BHC about which a considerable amount of information is now available from the Department of Agriculture's other field trials. Both aldrin and dieldrin are considerably cheaper than gamma-BHC in the formulations at present available, and in laboratory tests aldrin compares favourably with gamma-BHC.

The trial is being conducted on plots of five acres, and each of the five treatments has three replicates. Each treatment consists of two applications of 2 oz. toxicant per acre in 5 gallons aqueous emulsion with an eight week interval between the first and second applications. All plots received the first application during September by the Department of Agriculture Spraying Team using 'Motoblo' mistblowing machines.

In addition to the primary objective the effect of these five insecticides on the ant population is also being assessed.

Methods of Application of Insecticides

While the efficiency and reliability of several portable powered machines has been proven in the Gold Coast, their cost - approximately £70 each - and the difficulty in maintaining them, presents a formidable barrier to their widespread use by the majority of the Gold Coast farmers. As the successful long-term control of Capsids will require the participation of the individual farmers, search is continuing for a piece of equipment which is neither expensive nor difficult to maintain. This, of course, implies the use of hand operated machinery. In field trials which have

been .../

been carried out during the quarter, one of the hand operated machines under test has proved to possess the required qualities. It is the 'Leo-Colibri' No.8, pressure retaining knapsack sprayer fitted with a 13 ft. bamboo lance and a low-volume nozzle. The sprayer is robust and is comparatively cheap, the complete equipment costing approximately £23. With the high working pressure - up to 110 lb./sq. in. - and the low-volume nozzle the insecticide is applied as a wide-angle cone of fine mist which drifts through the canopy. No difficulty has been experienced in manipulating the long lances through the cacao canopy.

The output can be varied from approximately 4 to 14 gallons per hour by using nozzle caps with different sized apertures in conjunction with fine on coarse spiral internals.

In the field trial to control capsids in damaged mature cacao with this sprayer two applications of 0.5% gamma-BHC at the rate of 6 gallons per acre were made, the first in July and the second in August. Regeneration has been good and there has been no further capsid attack.

Further trials are being started on larger plots using gamma-BHC, dieldrin and aldrin.

Investigation of Fungi associated with Capsid lesions

Dissemination

Seven hundred and forty-one insects belonging to 64 families have been examined for the presence of Calonectria rigidiuscula (Berk & Br.) Sacc., and 15 in 9 families have been found contaminated with it. The internal fungus flora of capsids is being investigated by plating out the contents of the alimentary tract on cassava - 2% dextrose agar. Twenty-two capsids have so far been examined but none has been found contaminated with C. rigidiuscula. This fungus has not yet been isolated from surface-soil samples collected under cacao on the Old Station or Square Mile, though thirty-two have been examined.

Factors affecting Host Reaction

The effects of deliberate defoliation and a combination of pathogens have been investigated in an experiment on 8-month-old seedlings. The treatments were repeated defoliation (leaving no more than two mature leaves at the top of each plant) superimposed upon needle-inoculation with C. rigidiuscula and Botryodiplodia theobromae Pat., singly or together. Seedling height was recorded weekly and the length of the lesions which developed round inoculation sites was measured after 11 weeks. Neither fungus alone affected seedling height, but the two together appeared to have retarded the growth of defoliated plants after 4 weeks ($P = 0.10$) and had done so significantly by 9 weeks ($P = 0.05$). After 8 weeks, growth of the plants with a normal complement of leaves was apparently reduced, though not significantly ($P = 0.10$). There was some indication that removal of leaves had increased lesion length slightly ($P = 0.20$). The length of lesions in plants inoculated with C. rigidiuscula alone was significantly increased ($P = 0.05$). Inoculations

involving .../

involving B. theobromae gave lesions no longer than those formed round punctures made with a sterile needle, but these were usually invaded by the same fungus.

Cultural Studies

A detailed study has been made of the metabolism of C. rigidiuscula in liquid culture. The fungus will utilize glucose, sucrose, maltose, mannitol or ethyl alcohol as a carbon source, and NO_3^- NH_4^+ or amino-acetic acid as a nitrogen source. Growth in NO_2^- is poor or non-existent, except when glucose is the carbon source. Sucrose is hydrolysed to monosaccharide sugars, and ultimately alcohol is produced. Amine(s) and ammonia are produced during metabolism, and the occurrence of ammonia is coincidental with the production of wilt in excised tomato seedlings. It is possible that ammonia is the toxic principle, as has been suggested by several authors working with other Fusaria.

Strains of Fusarium decemcellulare

The six strains received from Dr. Owen (see Quarterly Report No.42) are being compared with that numbered 61805 in the herbarium of the Commonwealth Mycological Institute, which is the most common at W.A.C.R.I. The main differences between the strains are in pigmentation, abundance of spores and their mode of production, growth rate, and pathogenicity (as measured by lesion length in cacao seedlings). Strain 710 develops slowly in culture and when inoculated into the host, while 613 develops quickly in culture but slowly in the host.

5. EXPERIMENTS ON ESTABLISHMENT AND MAINTENANCE

Shade and Manurial Trial

This 'black and white' experiment has been laid down on the old 1st Establishment Trial area with the object of improving low yielding, poorly developed cacao by the removal of excess shade and the application of a mixed fertilizer. The last selective thinning of shade over the whole area started at the beginning of the September rains. One dressing of fertilizer has been broadcast at the rate of one pound per tree.

Routine recording and maintenance of other trials and cacao areas continued. In the absence of Agronomist officers no further experiments have been designed this year.

6. SOIL FERTILITY AND MANURIAL REQUIREMENTS

Effect of Major Nutrients on Cacao

(i) Of the eleven 2^3 factorial NPK experiments laid down in 1953 and 1954 on Amelonado seedlings, only four are still functioning as they were originally designed. The four experiments are at Goaso and Poanu (1953) and Juaso and Biene (1954). Two more of the experiments have been continued at W.A.C.R.I. and Bunso, but both have shade removal factors superimposed on the fertilizer treatments.

In .../

In reviewing the general course of the trials, including those abandoned at various times, it is evident that the fertilizer which was "placed" in a circle of 1 ft. radius around the picquets at the beginning of the trials in many cases inflicted "placement damage" which is still being recorded as a depression in growth in the current diameter of seedling measurements. The "placement damage" suffered by the young seedlings is, perhaps, not unexpected as the 2 oz. of each fertilizer per picquet, which would be equivalent to 2 cwt. per acre if broadcast, was in fact applied at five times that concentration to the soil around the seedlings by the "placement" technique. The "placement damage" was particularly severe at Oyoko and it is still reflected in the seedling diameter measurements taken this year.

Seedling heights (1954) and Seedling diameters (1956) at Oyoko

Treatment	NIL	N	P	K	NP	NK	PK	NPK
Seedling ht. cm. (1954).	48.0	42.0	48.7	34.0	44.7	32.6	36.9	33.1
Seedling diameter cm. (1956)	2.09	1.69	2.02	1.56	1.81	1.46	1.69	1.43

At some other sites similar, though less pronounced "placement damage" is clearly evident and in view of this it will be necessary to establish new fertilizer trials on seedlings.

(ii) Two new fertilizer trials are being started on Upper Amazons which were planted by the Department of Agriculture in 1953.

One of the plantings (Apedwa - Plot 1080) is three acres in extent and will provide 64 plots for a 2^4 factorial NPKMg experiment with the highest order interacttion confounded. The soil is not in a fertile phase and as the shade is sparse it is possible that the trees may respond to fertilizers at an early stage. If it is decided later that a fifth factor should be included in the treatments, the existing design can be modified to a 2^5 confounded factorial experiment by adding the fifth treatment to the appropriate plots.

The other planting (Asiakwa - Plot 1050) is on an acid soil and is to be used to test N, P and Magnesian Limestone in a 2^3 confounded factorial experiment.

Routine work has continued on the other NPK trials on Upper Amazons, all of which are likely to produce substantial crops this season.

Soil Fertility Investigation on Clear-felled Land

The clearing of a 2-acre block at W.A.C.R.I. has been completed and Upper Amazon basket seedlings have been

planted .../

planted at 8 x 8 ft. under palm fronds. Tree cassava will be used to provide nurse shade as the palm fronds decay.

The effect of different soil treatments and ground-covers on the organic matter status of the soil and on the growth of the seedlings will be followed.

Pot Experiment on Seedlings

A pot experiment to compare the effects of nitrogen supplied in three different forms, namely, ammonium sulphate, sodium nitrate and urea, was started in July. The seedlings are being shaded so that they receive 66% of the incident light.

8. PLANT BREEDING AND SELECTION

Established Trials

Shade is being reduced by felling and poisoning. A large dead trees has recently fallen in the Eighth PTA, causing serious damage. Due to the severe drought the newly planted Third Clonal trial has had to be watered, but, this attention having been given it, establishment now seems fairly good.

The Colombian introductions are establishing themselves well.

New Trials

Hand pollinated pods are being distributed for four new Series II trials in the Gold Coast, and a number of Series I and Series II trials in Eastern and Western Nigeria.

Recent Results

A comparison of the present cropping of the varieties in the First Clonal trial with measurements of the girth of the young plants made in 1950 shows an interesting relationship. In general the stouter stemmed plants have proved to be the better yielders. This could form a basis for early rejection of poor selections. Confirmation that the same relationships hold with seedling material will be sought.

A co-variance analysis of the frequency of bad pods in the First Clonal trial was made for the 1955-56 season, in which for the first time such pods amounted to 10% of the harvest. After having corrected for the differences in total yield, the differences between the varieties in the number of bad pods they carried were sufficient for it to be considered that these were genuine differences in susceptibility. (Probability of this not being the case under 1 in 1,000.) An analysis on the 1954-55 crop from the Second Progeny trial yielded a similar result (probability under 1 in 100). In general, where a clone in the First Clonal trial was related to progeny in the Second Progeny trial, they were similar in their relative resistance or susceptibility.

These bad pods include rodent-damaged pods, mealy pods and black pods. Samples of the present crop

from .../

from the First Clonal trial are being passed to the pathologists for examination.

Girth and height measurement on Series I trials on Department of Agriculture stations have been analysed. There are wide differences in the overall growth of the cocoa at the various stations, growth being best at Bunso and Goaso and poorest at Oyoko. In all cases the greater vigour of the Amazon cacaos over Amelonado is showing itself.

Differences in the relative values of varieties at different stations can also be seen; these seem to represent differences in the responses of the varieties to soil or climatic conditions.

Pollination

An examination of the data collected from the First Albino plot shows that about 50% of the pods from the trees in the outer row of the 'albinos' show evidence of pollination from outside the plot. Allowing for a roughly equal proportion having been pollinated by trees inside the plot it would seem likely that self-pollination is not of common occurrence.

The trees in the centre of the plot, surrounded by two rows of 'albino' trees, show about 33% crossing to trees outside the plot, but the total number of pods harvested from them is small so that the estimate cannot be considered very precise.

9. COCOA PREPARATION AND QUALITY

A series of fermentation experiments on the 1956 main crop has been started.

11. INSECTICIDE AND FUNGICIDE STUDIES

Joint W.A.C.R.I. - Department of Agriculture Experiments to Control Ants in Contact Areas Around Treated Swollen Shoot Outbreaks

In conjunction with the Department of Agriculture a series of experiments has been started to investigate the control of ants in cacao surrounding treated swollen shoot outbreaks by spraying insecticides with high residual properties, and thus indirectly reduce mealybug activity and cause a slowing-up, or the prevention, of movement of infective mealybugs out of the contact tree area.

The preliminary experiments have been concerned primarily with the effect of the insecticide on ant activity. Three sites were chosen at each of which a thirty yard wide belt of cacao was sprayed with a 1% Dieldrin aqueous emulsion, particular attention being paid to the trunks including those of forest trees. The application was made with a 'Motoblo' mistblowing machine, and an equivalent of a minimum of 10 gallons emulsion per acre used.

An ant survey was carried out before the insecticidal application and re-surveys have been carried out at weekly intervals since that time. In the first plot, in which

organised .../

organised ant activity (including arboreal nests) was recorded on 156 trees at the initial survey, only 7 trees were found with such activity at the first re-survey and 5 at the second re-survey. At the eighth re-survey, which was carried out a few days ago, ten trees with organised ant activity were recorded, but no active nests were seen. There were also some forty trees on which a single or a few wandering ants were seen, suggesting that there has been a gradual re-infestation, probably to a large extent from outside the plot, with the diminution of the residual toxicity of the insecticide on the tree trunks.

At the first re-survey colonies of mealybugs which were examined were found to be unattended. Large droplets of honeydew secretion were attached to the adult females. One week later many of the colonies were covered with fungal and bacterial growth which had developed on the honeydew, and in many cases had caused the extermination of the colony.

It is clear that a 1% Dieldrin spray has a profound effect on the ant population and that indirectly the mealybug population is being greatly affected. It appears that perhaps in the small plots a second application of insecticide will be necessary and this treatment has therefore been included in the experiment. Observations are continuing.

It is of interest to note that in the Joint Comparative Insecticide Trial for Capsid Control (mentioned on another page of this report) no similar control of ants has been obtained, indicating that good coverage of the trunks with a comparatively high concentration of the toxicant is necessary.

Pollination Studies

(1) Entomological

(i) Routine Collections of Insects in Cacao Flowers.

Collections were continued during July and August, until the flower numbers became too low to make it worth continuing. The incidence of the various insects in flowers, in four plots at four different times of day, were as follows :-

Comparison of Plots : All Times Together

	Total no. of flowers	Insects/1000 flowers			
		Ceratopo-gonidae	Cecido-myidae	Ants and aphids	Others
I.T.A.	5016	3.6	16.3	0.6	20.●
Old Station	4752	2.1	35.6	1.0	15.8
Seedling Reserve M-Block - I	5016	2.3	15.9	0.8	18.5
Seedling Reserve M-Block - II	4884	2.5	20.3	0.8	18.4
Total	19668	mean:2.6	mean:21.9	mean:0.8	mean:18.3

Comparison .../

Comparison of Times : All Plots Together

	Total no. of flowers	Insects/1000 flowers			
		Ceratopo-gonidae	Cecido-myidae	Ants and aphids	Others
06.30-07.30	5016	1.4	20.5	0.8	16.0
10.30-11.30	5016	5.1	27.3	1.4	18.1
13.30-14.30	4884	3.5	18.2	0.6	20.5
17.30-18.30	4752	0.4	21.3	0.2	18.7

(ii) Breeding Sites.

Large numbers of Forcipomyia spp. have been bred out of old cacao pods, which had been eaten out by rodents and left hanging on the tree, and the hollow shell had become filled with water.

(iii) Pollination by Ants and/or Aphids.

A preliminary attempt to determine whether ants or aphids pollinate cacao flowers was made by enclosing separately 50 mature buds bearing colonies of aphids, with and without attendant ants. After the buds opened they were left covered until the flowers fell. No sets were obtained.

(2) Botanical

(i) An experiment to determine what proportion of sets result when cacao flowers are pollinated at various intervals after opening was carried out in July. Three trees, of type D/26, in the outer guard row of Clonal Trial II, were used, the flowers being covered before opening and hand-pollinated with pollen from self-compatible Amelonado trees. At 24 and 27 hours after opening, two sets of flowers were pollinated at each time, one on the stigma and one on the style; in each case, pollination on the style gave a somewhat higher setting rate. The results for the three trees combined were as follows :-

Hours after opening	Style or stigma	Number pollinated	Number set	Percentage set
2 - 5	stigma	31	24	77.4
8 - 9	stigma	35	30	85.7
11 - 12	stigma	35	35	100.0
24 - 25	stigma	23	9	39.1
24 - 25	style	22	11	50.0
27 - 28	stigma	27	3	11.1
27 - 28	style	35	5	14.3

(ii) .../

(ii) Comparison of natural pollination and setting rates on 36 trees throughout the year.

From the following table it can be seen that during the period June - August the number of flowers dropped steeply, as also did the percentage which fell within 24 hours of opening - i.e., fewer flowers were produced, but these remained on the tree for a longer period. The actual number of pollinations during these 12 weeks remained comparatively constant, while the number of sets showed a high peak at the end of July. Throughout the period the number of pollinated flowers which failed to set, and fell, was relatively high. During August - September the number of pollinations and sets both fell steeply, the percentage of flowers falling within 24 hours rose somewhat, and the tree started to flush.

	4-week periods ending			
	June 25	July 23	Aug. 20	Sept. 17
Mean no. flowers per tree	246.0	55.1	23.1	5.2
% of flowers falling within 24 hr.	55.7	14.3	9.7	14.7
Mean no. pollinations per tree	8.2	11.2	8.8	1.6
Mean no. sets per tree	8.0	16.6	6.6	1.8
Mean no. pollinated flowers fallen per tree	1.5	1.6	2.9	0.9

12. PHYSIOLOGY OF NUTRITION, GROWTH AND FRUITING

Investigation of Cherelle Wilt

The Effect of Increased Setting on Yield

The experiment which was described in Quarterly Report No.42 is continuing and results to date are as follows :-

	Hand-Pollinated Trees (20)	Natural-Pollinated Trees (20)
Pods Set	3830	3213
Pods Wilted	3177	2562
Pods Harvested	238	202
% wilted	82.9	79.7
Pods on trees at 26/9/56	415	449

...

There .../

There is no significant difference at this stage of the season between pods harvested but the natural-pollinated trees have produced their crop much earlier than the hand-pollinated trees due to excessive cherelle wilt on the latter in June.

An experiment on the effect of reducing setting on the yield of cacao trees is in progress but no results are available yet.

Cherelle Wilt in the Trinidad Introductions

Records from the Trinidad Introductions indicate that the highest yielding selections have the lowest percentage wilt, but that this does not necessarily hold within a selection. The average for 30 selections in this area from January to September was 75%, but T12 for example had a figure as low as 52%. There is an indication that types with a Nanay female parent have a percentage wilt significantly below the general mean for the Introductions Area.

Frequency of Harvesting

An experiment was begun in conjunction with the Mycologist at the end of June to compare weekly versus monthly harvesting on three selections in the First Clonal Trial. This was laid down as previous experiments of this nature had shown a difference in pods harvested on weekly as opposed to monthly harvested plots. In this present experiment counts are taken weekly of flowers, wilted cherelles, healthy cherelles, pods and flushing. A significant yield difference between harvesting treatments has once again been observed and the figures are being analysed to trace the causes of this.

Experiments with Radioactive Phosphorus

An experiment has begun to examine the rate of uptake of P^{32} by cocoa trees from the soil throughout the year. Uptake even in the very dry conditions of July and August was surprisingly rapid, and appreciable counts of radio-activity from the leaves were regularly obtained less than one week after applying 720μc P^{32} to the soil around a young Amazon cacao tree coming into bearing. The mass of data from these experiments is being analysed at present.

Needle counters have now been obtained and work is in progress to trace the movement of P^{32} in the tree by inserting these needles at different levels in the stem and measuring the counting rate. If a correlation can be obtained between counts from these needles and total P^{32} in the wood or bark, then it will be possible to trace movement without destroying the tree.

ADDITIONAL INVESTIGATIONS AND OBSERVATIONS

Ant Damage to Pods

On several occasions during August ants were found attacking cacao pods. As there appear to be no records of this type of damage it is considered worthwhile noting it in this report.

Workers .../

Workers of the ant species Crematogaster (Atopogyne) africana were removing small pieces of skin from pods and cherelles and carrying the material back to the nest. At Bosuso, cherelles of about 1½ inches long, were seen which had been completely skinned. These cherelles fell from the tree during the following week. Several trees were found at Bunso Plantation on which nearly mature pods had been similarly attacked, giving the pods a black mottling which in some cases completely covered the pod. There was no indication of the entry of fungi through the wounds. This ant species was also observed to be removing the skin from pods of Herrania at W.A.C.R.I.

Crematogaster (Atopogyne) africana is an arboreal nesting species and is important in the entomology of swollen shoot because of its close association with colonies of Pseudococcus njalensis in Canthium.

Entomological Aspects of Personnel Health:
Transmission of 'Filaria' parasites
(Acanthocheilonema streptocerca) by Culicoides spp.

Following the discovery by Dr. Duke, of the Helminthiasis Research Unit, British Cameroons, that there is a high incidence of infection by A. streptocerca in the local African population, an investigation has been started into the transmission of this parasite by 'sandflies' (Culicoides spp.)

Collections were started in September to determine the percentage parasitism in biting female flies. Two assistants, (both themselves apparently free from infection), are sent to 4 selected sites and catch all flies alighting on them; these are then examined for parasites.

Culicoides is most active in the early morning and at dusk; the greatest number of flies are caught in the morning, in bush or cacao, and fewest in open spaces (i.e. the golf-course), in the evening.

So far, 232 flies have been dissected, of which 2 were carrying one microfilaria each, and one contained a single infective stage of the worm in the thorax. Thus, 1.3% of flies examined were infected with parasites of any stage, and 0.4% with those at the infective stage.

IBADAN SUB-STATION

Senior Staff Mr. C.S. Wishart arrived on 16th July. He has been posted to W.A.C.R.I. by Messrs. Plant Protection Ltd. to assist with the experiments on the chemical control of cacao capsids during the present shortage of Senior Staff at the Sub-station.

Buildings The new laboratory building at Moor Plantation has been completed, except for the installation of a telephone.

Visitors .../

Visitors His Excellency Vice-Admiral Don Faustino Ruiz, Governor-General of the Spanish Territories of the Gulf of Guinea, visited Moor Plantation on 10th September. Dr. Walter Carter spent several days with the staff of the Sub-station during his visit to Nigeria in July.

Western Region Agricultural Officers' Conference Messrs Donald and Thresh read papers on Capsid Control Experiments and Swollen Shoot Disease of Cacao, respectively, at the conference convened in July by the Director of Agriculture, Western Region of Nigeria.

VIRUS RESEARCH

Coppicing Experiment at I.N.A. Farm

Observations have continued on the various coppicing experiments at the Ibadan Native Administration cacao farm near Ibadan. Routine operations now include spraying against black-pod disease, because chupons on the stumps of most of the trees coppiced in 1954, and on some of those coppiced in 1955, are now bearing pods. As many as twenty-five full-sized pods are ripening on some of the chupons and it appears that under the conditions in this area the first significant yield of pods is produced in the second or third main crop season after coppicing, depending upon the time of year at which this operation is carried out.

In Quarterly Report No.40 it was pointed out that chupons on the larger stumps tended to grow more rapidly than those on the smaller ones. This observation has been confirmed in additional experiments, including several in which measurements were made two years after coppicing.

Preliminary observations, which were referred to in the 1954-55 Annual Report, suggested that the rapidity with which chupons grow after coppicing is unaffected by the severity of the canopy damage on the trees at the time they are coppiced. But these observations were made during the first few months after coppicing, and observations made after two years show that chupons growing from the coppiced stumps of severely damaged trees make significantly less growth than those on the stumps of undamaged, or slightly damaged, trees. Two possible explanations of this effect are that the root system of damaged trees may have been impaired by repeated capsid attack and die-back, or that the most severe canopy damage is shown by trees growing in relatively unfavourable conditions. Moreover, the growth of weeds and grasses is more vigorous in areas where the cacao canopy was broken at the time of coppicing and ground vegetation already established. Competition for water and/or nutrients between the cacao and the ground vegetation might account for the relatively unsatisfactory growth of the chupons in these areas.

A black spider-mite has been found in large numbers on the undersides of some of the oldest leaves on chupons growing from stumps coppiced in 1954. The mite found in the field resembles the one which occasionally appears on old plants kept in insectaries, and the leaf

damage .../

damage it causes is similar. Severe attack by spider-mites is rare on cacao in the field, and this record may be connected with the regular and intensive spraying which has been practised during the last two years at I.N.A. farm, where Gammalin or D.D.T. has been applied at monthly intervals.

Availability of Cacao Swollen Shoot Virus in Mature Trees

A series of experiments has been started to investigate the distribution and availability of cacao swollen-shoot virus in mature trees with different stages of symptom expression. The results of the first experiment indicate that the availability of virus to mealybugs varies with the intensity of symptom expression. Virus was readily transmitted from both symptom-bearing and symptomless branches of trees which were showing extensive symptoms; but there were few or no transmissions from trees which were passing through a symptomless phase of infection, or showing only few symptoms.

The Control of Cacao Swollen Shoot Virus in Nigeria

A second assessment has been made of the data from the 123 outbreaks which have been treated by grubbing out the trees found with symptoms and coppicing the remaining apparently healthy trees to a distance of thirty yards from the nearest infection. The number of latent or undetected infections which have been revealed by coppicing remains small in relation to the total number of trees coppiced, and as a result, a modified cutting-out policy has now been adopted in the Area of Intensive Survey. Under the new scheme the trees found with symptoms are grubbed out, and the surrounding apparently healthy ones are treated to a distance of 5 yards from the nearest known infection when the number of symptom-bearing trees is less than 10, to a distance of 15 yards when it is between 11 and 50, and to a distance of 30 yards when it exceeds 50. The treatment for apparently healthy trees is to grub them out when they occur within 5 yards of a known infection and to coppice them if they are more distant. The new policy is not intended to be a final recommendation for the most efficient and economical control of swollen-shoot disease; it is a compromise which allows the collection of additional information on the number and distribution of latent and undetected infections, while at the same time avoiding the excessive destruction of healthy trees which appears to have occurred previously, particularly in the treatment of small outbreaks.

Nigerian Isolates of Cacao Virus

Fifteen virus isolates are being studied in the detailed experiments now in progress at Moor Plantation. Ten of these are transmitted by mealybugs and can be distinguished from each other with varying facility by the symptoms they produce on cacao. The remainder have not been experimentally transmitted by mealybugs and are characterised by severely necrotic initial symptoms on young saplings. Their symptoms vary in detail with the size of plant infected and the way in which it is treated. If one-year-old saplings are infected with patch grafts and then cut back, the new flush leaves usually show extensive

vein- .../

vein-necrosis and die before becoming fully hardened. Most of the developing shoots then wilt and die back, so that the appearance of the plants at this stage is striking. Some are killed, but usually additional shoots begin to develop and these grow normally, except that occasional leaves show clear transparent patches along the midrib and secondary veins. This symptom appears to be the characteristic one produced by these isolates on mature trees in the field.

A range of Nigerian Swollen-shoot isolates have failed to protect saplings against subsequent infection with the necrotic ones. This fact, along with their unique symptoms and the consistent failure of mealybugs to transmit them, is considered to be sufficient justification for regarding the necrotic isolates as representing a virus distinct from swollen shoot; therefore the name cacao necrosis virus is proposed.

CAPSID STUDIES

Chemical Control of Capsids

Insecticidal application in the capsid control trials commenced on 30th July. Unfortunately the dust treatment (Gammalin 3 at the rate of 4 oz. gamma BHC per acre) had to be witheld until the second monthly application, owing to the late arrival of hand dusting machines. Commencement of the "spot treatment" with dust where damage is found, following two overall dustings at monthly intervals, will therefore be delayed one month.

High-volume treatment with 4 oz. gamma BHC in 25 gallons of water per acre was found to be impracticable when using the "Four Oaks" pneumatic knapsack sprayers fitted with a fine mist nozzle, as the rate of delivery from these nozzles was too slow. A few preliminary trials before the second monthly application of insecticide showed that it was possible to reduce the volume of water to 10 gallons per acre, a rate now adopted for this particular treatment. In spite of this reduction, the time taken for one operator to treat an acre is $2\frac{1}{2}$ - 3 hours.

The third monthly application of insecticide is now being carried out. As capsid damage is not extensive at this time of year, no significant results can be expected from assessment of this or canopy condition in the treated plots until later in the season, although the effect of treatments on the population of the insects themselves appears to be encouraging. The following observations based on preliminary examination of data already to hand, though not yet subjected to statistical analysis, are of interest :-

(i) Capsid numbers continued to increase steadily from month to month in the untreated plots up to the time of the second spraying cycle, when they were about $2\frac{1}{2}$ times as great as in June.

(ii) The first applications of liquid formulations of gamma BHC at rates of 2 oz. and 4 oz. of active ingredient per acre reversed the trend noticed in the untreated plots, reducing the capsid population to about half its pre-treatment level.

(iii).../

(iii) Capsid populations after the second monthly application of 4 oz. gamma BHC per acre had been further reduced to about one-eighth of the pre-treatment level in July, which represents a reduction in the expected population in the absence of treatment by about 90%.

(iv) Capsid populations in plots which received a second application at 2 oz. gamma BHC per acre and in those which were to be treated only at 8-weekly intervals were not further reduced, but no increase in populations was observed when the last counts were made.

(v) One dusting with Gammalin 3, which is all that has been done to date, reduced the population to about one-quarter of the level to which it had risen before the belated application of dust was possible.

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